# SEC Future Programs

- **Technology Overview - Art Poland / GSFC**

# SEC Technology Overview

- Identification of technology needs is driven by SEC science requirements.

- The SEC Technology Working Group was established to develop a technology roadmap that will be integrated into the SEC Roadmap. The new technology roadmap is being developed with participants from NASA, universities, and industry.

- Technology requirements center around three general areas:
  - Instruments & Instrument Components
  - Spacecraft Systems
  - Transportation & Mobility

# Instruments and Components

## Introduction

- **Instruments:**
  - Measurements are driven by science questions.
  - New instruments are designed by scientists and engineers to improve measurements.
  - Scientists who will use the measurements need to be active participants in the instrument development process.

- **Components:**
  - Some instrument elements (e.g. optics, detectors) are frequently built with strong science oversight.
  - Other general components (e.g. computers, electronic subsystems) are frequently purchased from industry.

- **Instrument Technology Needs:**
  - Innovative instruments
  - Miniaturized sensors

# Innovative Instruments

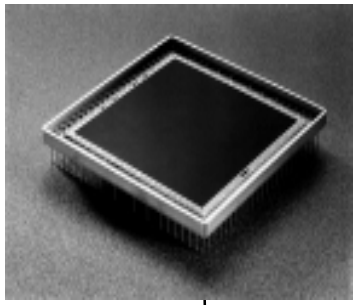
- **New techniques to observe physical parameters that:**
  - Cannot now be measured
  - Fill critical measurement gaps that limit our understanding of physical phenomena
  - Measure with greater certainty key parameters that now can be inferred only indirectly
  - Open new frontiers of space physics exploration

- **Examples:**
  - Very Low Energy (Sub-keV) Neutral Atom Imaging (H, D, He, Li, CNO)
  - Electrical current density measurements
  - Dust mass/charge spectrometry
  - Solid-state X-ray imaging spectrometer
  - UV polarization to measure the magnetic fields in the outer solar atmosphere
  - Six-dimensional detectors (spatial, energy, polarization, time)

# Detector Technology

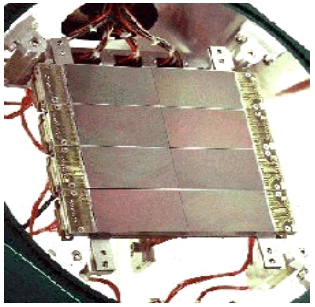
Capabilities

Current technology is CCD Arrays giving I(x,y) and time

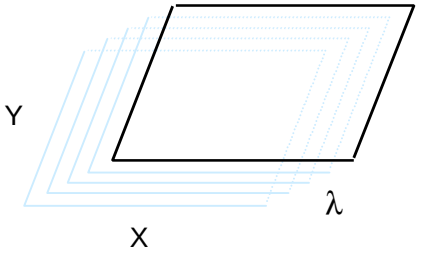


Advanced Technology

I (x,y,energy) and time with good energy separation over limited wavelengths



- Ultraviolet
- Isolate specific emission lines at various wavelengths




Complete 3D + time

- All wavelengths, X-ray to infrared
- Excellent spatial, wavelength, time resolution
- perhaps polarization (a 4th dimension)

5 10 15 20 25

Years

# Detector Technology

- **Science Drivers:**
  - We need to be able to measure the temperature, density, velocity, and magnetic field of various objects and places.
  - It is only by measuring these quantities that we can understand what we are looking at.
  - These quantities are needed for computer models that predict what will happen.
  - Current capabilities do not allow us to measure them simultaneously, thus leading to uncertainty.

- **Technical Capability:**
  - We are currently able to get number of photons as a function of position. (these are 2D detectors).
  - We need further separation in energy such that we can measure the Doppler shift of spectral lines so we can get velocity.
  - Measurement of the polarization of the photons will give us the direction and strength of the magnetic field.

# Miniaturized Sensors

- **Advanced Technology is needed to:**
  - Consume less spacecraft resources
  - Use less mass
  - Optimize detection efficiency for better space, time, and energy resolution

- **Examples:**
  - Miniaturized and/or optimized designs for the collector component of space instruments (e.g. photon or particle optics, antennas, probes)
  - Miniature MEMS magnetometer probe
  - Integrated CCD/active pixel sensors for charged particles
  - Compact, lightweight energetic particle detectors (< 1 kg)
  - Solid-State X-ray imaging spectrometers
  - Light-weight deployable booms

# Sensors and Instruments: Summary

- Improvements in sensor performance and reductions in instrument resource requirements will directly enable the utilization of compact, light weight spacecraft.

- SEC needs for new sensors and instruments can be accomplished by a competitively selected, peer-reviewed program for SEC instrument design and development.

- An early technology program with active scientist participation can greatly enhance the capability of future missions while significantly reducing development risk.

# Spacecraft Systems: Introduction

- **SEC spacecraft technology needs fall into two general categories:**
  - Many small spacecraft to take many in-situ measurements of interplanetary and geospace
  - Relatively larger systems to make remote sensing measurements of the Sun and Earth
- **System technology needs:**
  - **In-situ**
    - lightweight
    - enable constellation/formation flying
    - advanced materials, mechanisms, and packaging
  - **Remote sensing:**
    - high data rate communications
  - **Both:**
    - power systems
    - harsh environment survivability
    - radiation hardened/tolerant space data systems

# Constellations

- **What is needed:**
  - Lower component costs through the use of standard and configurable components
  - Lower I&T costs through use of standards and configurable components and automated assembly and testing
  - Innovative architectures to coalesce functions
  - Software standards/re-use to allow low cost functional extension and adaptability
  - Lightweight S/C to minimize launch costs

- **Path to achievement:**
  - Allow acquisition of large number constellations of satellites
  - Minimize time and cost of assembly and test
  - Improve reliability through re-use of thoroughly tested components
  - Partner with industry to establish a production line



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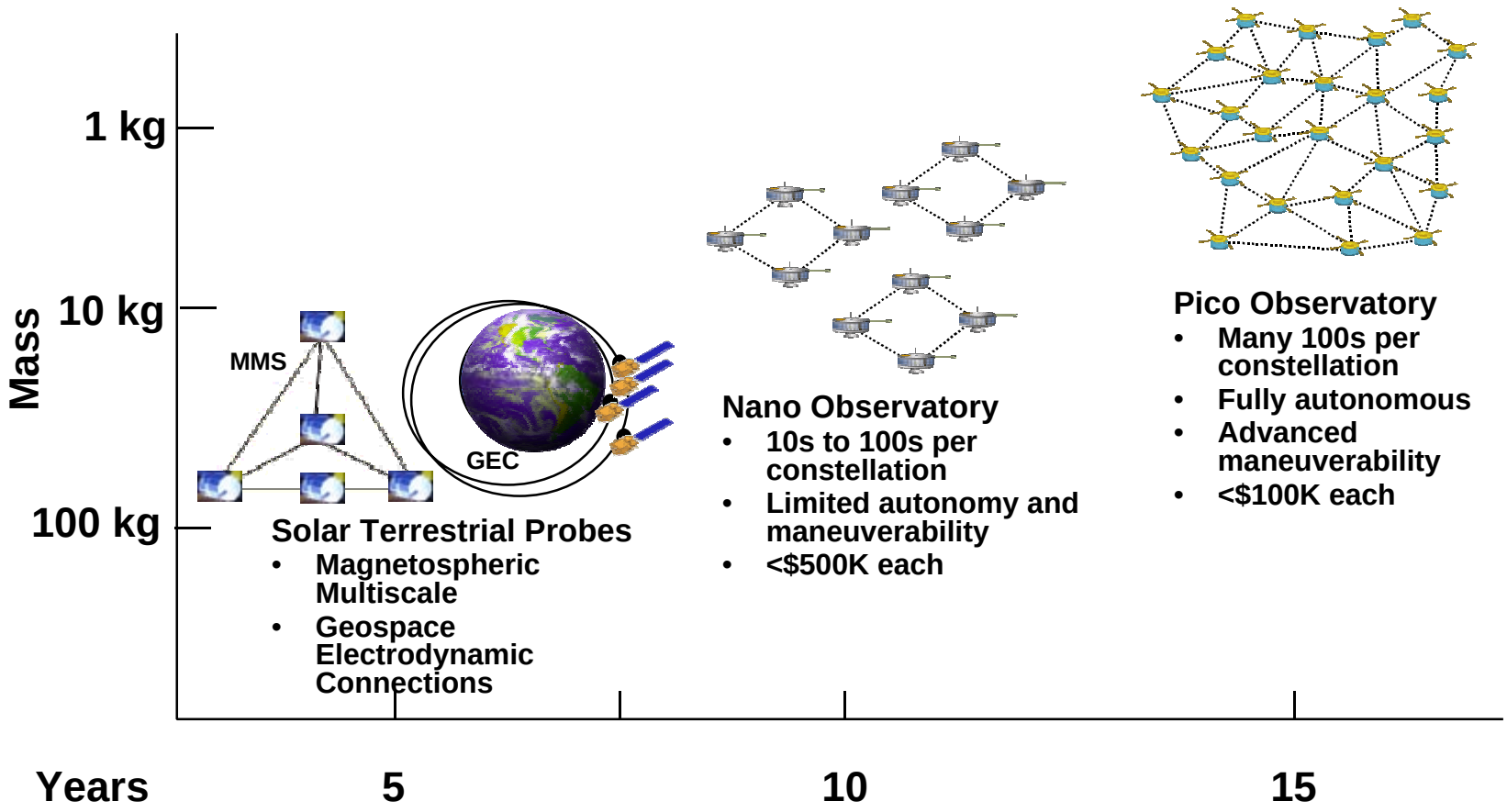
# Constellation Roadmap




**Revolutionize the multipoint remote and in-situ scientific investigations of key physical processes in the SEC Theme by creating new generations of high performance, integrated spacecraft observatories which are dramatically lighter, compact, and cost-effective.**



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# Spacecraft Systems Conclusion

- **There is a wide range of spacecraft systems development that could be of benefit to SEC:**
  - Miniaturization
  - Formation flying systems
  - Radiation hard subsystems
  - Advanced communication
- **Almost all of these advances would be of benefit to other disciplines besides SEC.**
- **Partnerships with industry should be developed to reliably and dependably produce these items.**



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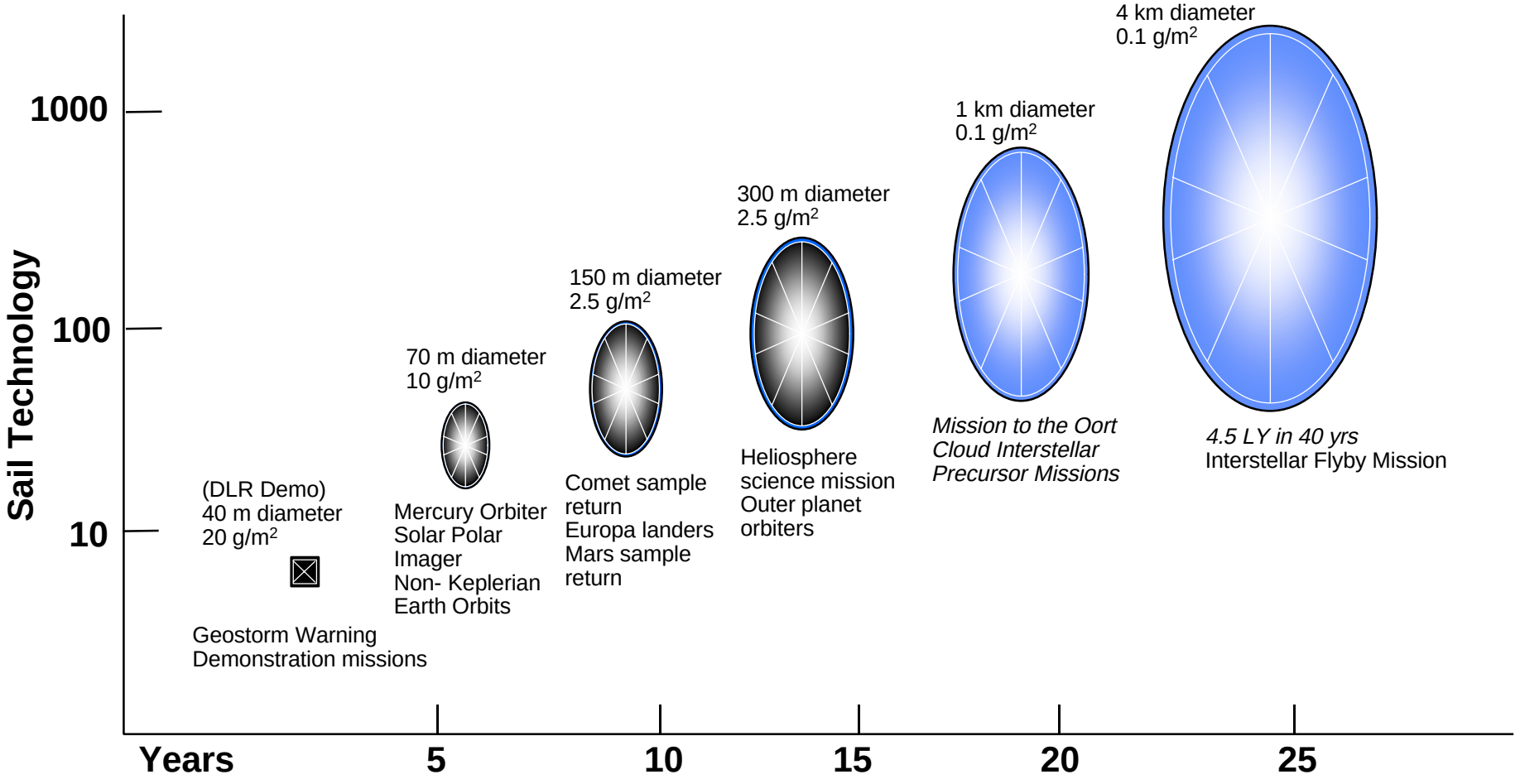
# Transportation and Mobility

- **SEC needs advanced propulsion systems to achieve the following science objectives:**
  - High energy orbits in the solar system
    - Solar Probe to get close to the Sun
    - Solar Polar
    - Interstellar Probe
  - Non-Keplerian orbits for specific vantage points
    - Solar Sentinels (0.95 AU)
    - Earth Pole Sitter
- **Other disciplines and enterprises have similar propulsion system needs.**

# Solar Sail Roadmap

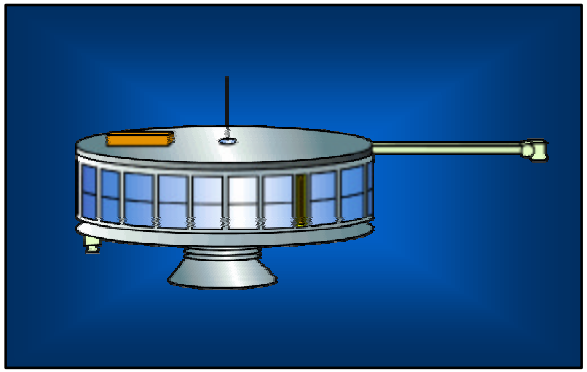



Solar sail propulsion enables new types of missions and dramatically lowers trip times for travel throughout the solar system and beyond.

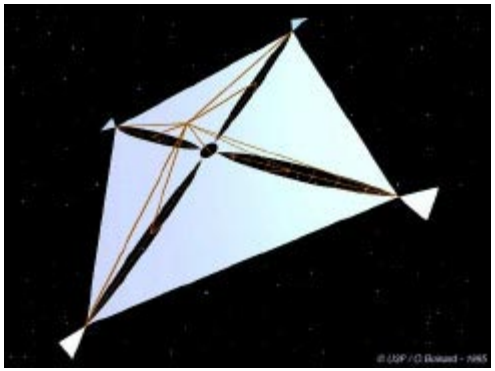
# SEC Proposals for the New Millenium Program

## Space Technology Mission - 5

- **Process:**
  - Select themes for SEC and SEU missions
  - Identify technology challenges
  - Release call (FRP) for technologies
  - Select technology providers for each theme
  - Each theme develops proposal
  - Mission selected
  - AO for science instruments released
  - Instruments selected - mission is implemented
  - Launch in 2003



- **Nanosatellites:**
  - Small (spinning) spacecraft, deployed and operated in constellations
  - Each with multiple small fields and particles instrument technologies



- **Solar Sails:**
  - Propulsion system to place spacecraft in desired locations unreachable (or un-maintainable) by alternative propulsion systems
  - Small fields and particles instrument technologies (on bus, sail or sub-sat)



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# Technology Summary

- **SEC technology needs lie in 3 main areas:**
  - Instruments, Spacecraft, and Transportation

- **Other disciplines and enterprises will benefit from our enabling technologies, such as solar sails and miniaturized spacecraft.**

- **Advanced development in the areas of instruments and instrument sub-systems could significantly enhance future mission capability while reducing mission risk. This can be accomplished by a competitively selected, peer-reviewed program for SEC instrument design and development.**